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EDITORIAL COMMENT

The Cardiorenal Connection

New Insights Toward Choice of Revascularization*

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The incidence of acute kidney injury (AKI) varies widely after coronary revascularization, likely because of the incorporation of studies spanning 3 decades, different definitions used to define AKI, and variation in the use of volume expansion and iso-osmolar contrast media protocols. Recent widespread adoption of the Acute Kidney Injury Network classification system (**Table 1**) has provided us with useful estimates of AKI using standardized definitions. A recent estimate of the incidence of AKI after percutaneous coronary intervention (PCI) in 985,737 patients from the contemporary National Cardiovascular Data Registry was 7.1% (1). There is a paucity of data on AKI after coronary artery bypass grafting (CABG) using the Acute Kidney Injury Network definition. The incidence of AKI was 19.8% in a recent study with a small sample size (2).

The etiologies of AKI after PCI are poorly understood but are believed to be related to contrast-mediated acute tubular necrosis resulting in medullar hypoxia or to direct cytotoxic effects of contrast agents. Tubular injury may be exacerbated with renal vasoconstriction. The etiology of AKI in patients undergoing CABG, in contrast, includes intraoperative hypotension, postoperative complications that limit renal perfusion, atheroemboli, and reperfusion injury.

Regardless of the etiology, the presence of AKI is a predictor of poor outcomes after coronary revascularization. AKI is associated with increased risk for myocardial infarction, bleeding, dialysis, and poor short-term and long-term survival (2–4). Even a small increase in serum creatinine is associated with very poor survival (5). Not only does AKI itself lead to adverse outcomes, but it is also associated with higher bleeding rates (**Table 2**). The predictors of AKI after revascularization are the acuity and severity of presentation (acute coronary syndrome or ST-segment elevation myocardial infarction and cardiogenic shock), congestive heart failure, pre-existing chronic kidney disease, contrast medium use, and the presence of diabetes mellitus (1). Excellent predictive models are now available to aid clinicians in the prediction of AKI (6).

Comparative effectiveness research educates physicians and patients on the risks of PCI and CABG. Armed with that information, it helps physicians and patients choose among alternative approaches and aids in patients' clinical management. Randomized clinical trials have traditionally been used to compare treatment efficacy, but they have limited use in "real-world" practice because of stringent enrollment criteria and small sample sizes, limiting the generalizability of their conclusions. They are less suitable for examining variations in clinical effectiveness across patient populations treated in typical practice settings.

Current efforts comparing the effectiveness of PCI versus CABG in patients with multivessel disease, from retrospective, observational data, have advanced our knowledge and will likely help in the selection of PCI or CABG as a revascularization strategy. Previous attempts clearly defined a survival advantage of CABG over PCI in subsets with diabetes mellitus, congestive heart failure, and peripheral vascular disease, as well as smokers (7,8).

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The present study illustrates the importance of AKI after coronary revascularization, which may influence the choices made by patients and providers. Chang et al. (9), in this issue of the *Journal*, report 2- to 3-fold higher adjusted risk for AKI in patients undergoing multivessel revascularization with CABG compared with PCI. The investigators studied 2 cohorts (Kaiser

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TABLE 1 Classification/Staging System for Acute Kidney Injury

Stage	Serum Creatinine Criteria	Urine Output Criteria
1	Increase in serum creatinine of ≥0.3 mg/dl (≥26.4 μmol/l) or increase to ≥150% to 200% (1.5- to 2-fold) from baseline	<0.5 ml/kg/h for >6 h
2*	Increase in serum creatinine to >200% to 300% (>2- to 3-fold) from baseline	<0.5 ml/kg/h for >12 h
3†	Increase in serum creatinine to >300% (>3-fold) from baseline (or serum creatinine of ≥4.0 mg/dl [≥354 μmol/l] with an acute increase of ≥0.5 mg/dl [44 μmol/l])	<0.3 ml/kg/h for 24 h or anuria for 12 h

Adapted from the RIFLE (risk, injury, failure, loss, and end-stage kidney disease) criteria. The staging system proposed is a highly sensitive interim staging system and is based on recent data indicating that a small change in serum creatinine influences outcome. Only 1 criterion (creatinine or urine output) has to be fulfilled to qualify for a stage. Mehta RL, Kellum JA, Shah SV, et al. Acute Kidney Injury Network: report of an initiative to improve outcomes in acute kidney injury. Crit Care 2007;11:R31. *A 200% to 300% increase is equivalent to a 2- to 3-fold increase. †Given wide variation in indications for and timing of initiation of renal replacement therapy, patients who receive it are considered to have met the criteria for stage 3 irrespective of the stage they are in at the time of therapy.

TABLE 2 Incidence of Death, Bleeding, and MI Stratified by AKIN Stage

AKIN Stage	Death (%)	Bleeding (%)	MI (%)
No AKI	0.5	1.4	2.1
1	6.6	5.4	3.3
2	24.6	11.4	5.9
3	23.4	9.5	5.7

Reprinted from Tsai et al. (1).
AKI = acute kidney injury; AKIN = Acute Kidney Injury Network; MI = myocardial infarction.

Permanente Northern California and Medicare beneficiaries) and found a higher incidence of AKI in the Kaiser Permanente cohort (20.4%) compared with older patients (6.2%) enrolled in the Medicare cohort. The incidence of dialysis at 90 days after the index procedure was 15% in the Medicare cohort in patients with underlying chronic kidney disease.

There are significant limitations in the present analyses that must be underscored. First, derivation from administrative database can lead to ascertainment bias. The incidence of AKI was lower in the Medicare population than in the younger population in the Kaiser Permanente Northern California cohort. Second, the data spanned 13 years. The risk profiles of patients and strategies to prevent and treat AKI have evolved, such that reporting of secular trends for AKI would add meaningful information to the present study. Third, the study's retrospective nature and its use of propensity analyses for matching (poor for Medicare patients) would lead to biased estimates due to residual confounding. Fourth, knowledge of coronary anatomy, its complexity, and the availability of SYNTAX (Synergy Between PCI With Taxus and Cardiac Surgery) score would have provided important knowledge to readers. Fifth, in patients undergoing PCI, the incidence of AKI may be lower because these patients are discharged the day after the procedure, and increases in serum creatinine may occur after dismissal.

Notwithstanding these limitations, this study has significantly advanced our knowledge and will help us in the selection of revascularization. In patients with multivessel disease, diabetes mellitus, low ejection fractions, high SYNTAX scores, or peripheral vascular disease, improved survival with CABG has been demonstrated (10). However, patients with low SYNTAX scores and with baseline chronic kidney disease can be favorably treated percutaneously. There is an evolution in our thinking as we strategize the choice of revascularization for an average patient, taking into consideration some readily available covariates.

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